Precision X-band RF control system.

Towards higher timing resolution…

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Motivation & Challenges

For given beam optics, the limiting factors for the timing resolution of a Transverse Deflecting Structure (TDS) are operating frequency and electric field strength:

$$res \sim \frac{\sqrt{P}}{k}, k \sim \frac{1}{f}$$

Two ways to increase the timing resolution:

1. Increase the frequency → increase linearly
2. Increase the power → increase by square root

New X-band structure: Polarizable X-band TDS (PolariX TDS)

- Collaboration between CERN, PSI and DESY
- Variable polarization
- 12 GHz resonance frequency
- **Requires new RF frontend at X-band**

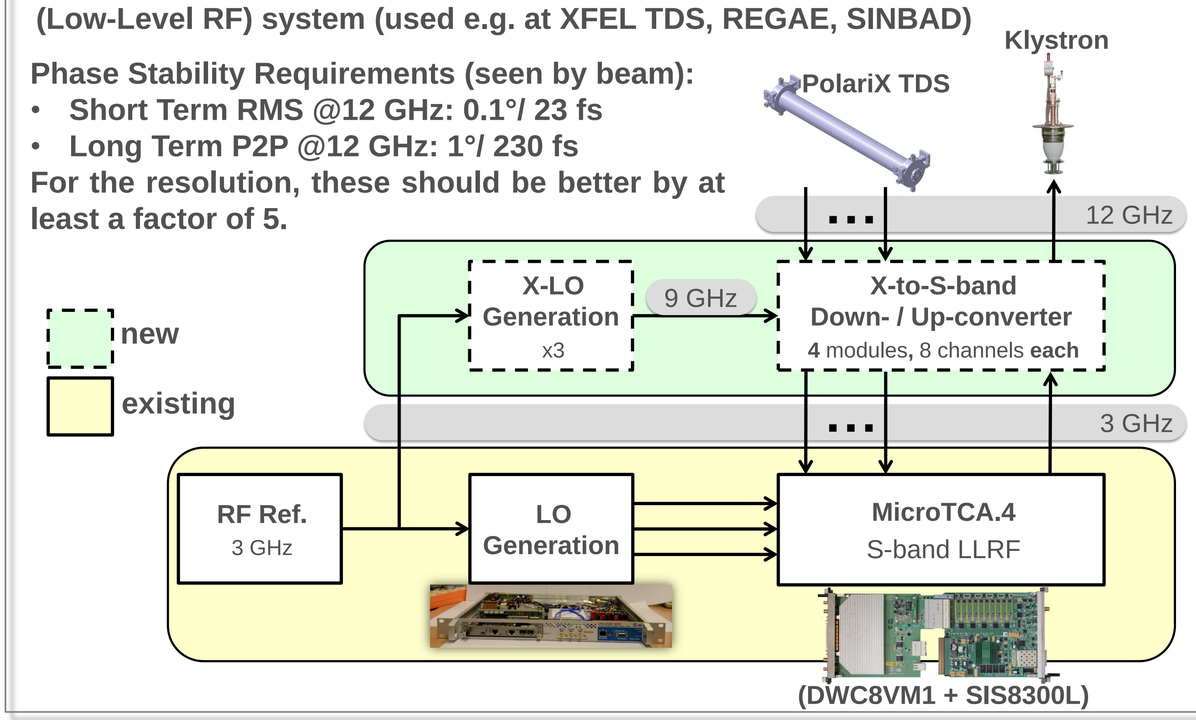
Overview of Concept

Idea: Use X-band frontend, mix down to S-band and use a standard S-band LLRF (Low-Level RF) system (used e.g. at XFEL TDS, REGAE, SINBAD)

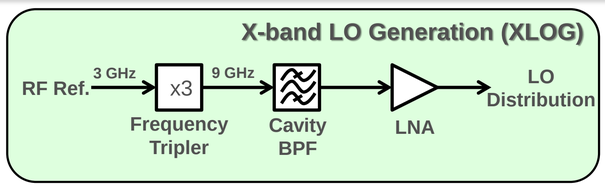
Phase Stability Requirements (seen by beam):

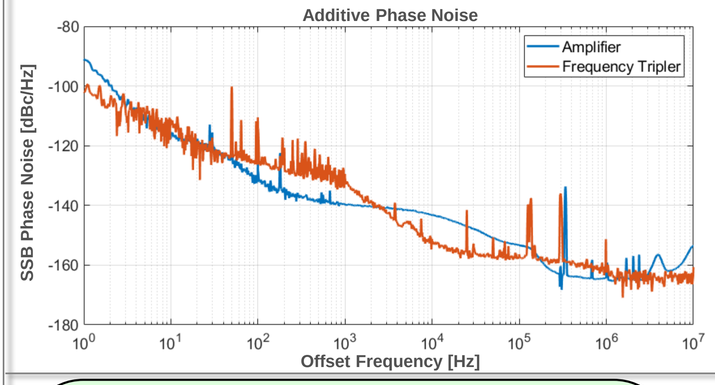
- Short Term RMS @12 GHz: 0.1°/ 23 fs
- Long Term P2P @12 GHz: 1°/ 230 fs

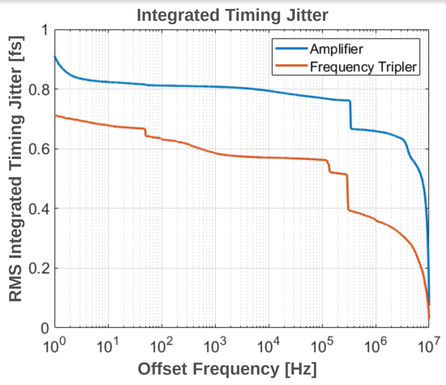
For the resolution, these should be better by at least a factor of 5.



Measurements



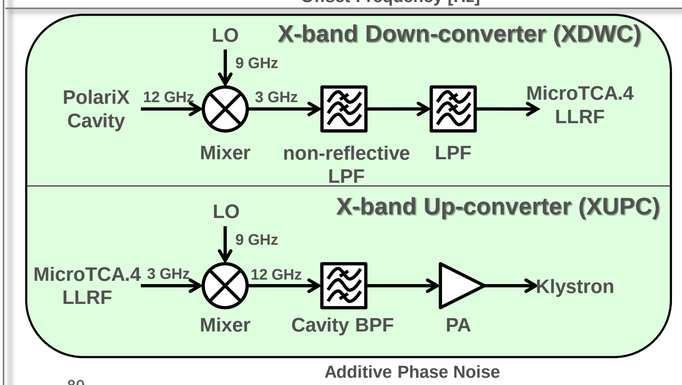


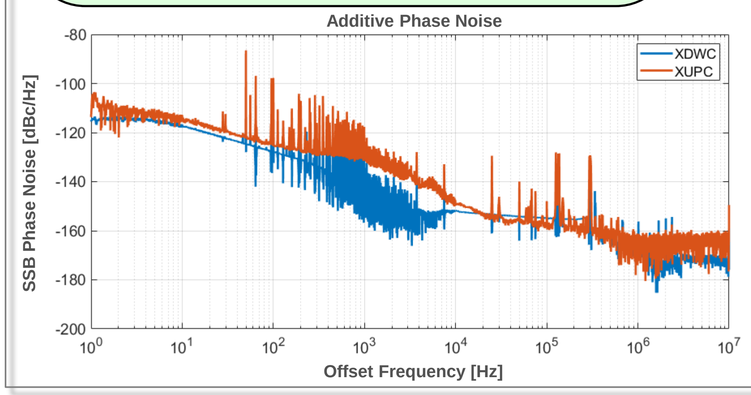


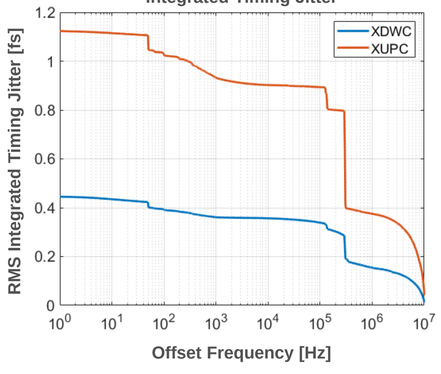
Short term jitter* @ 12 GHz:

- 3.94 m° / 0.911 fs (Amplifier)
- 3.98 m° / 0.713 fs (Tripler)

→ 5.00 m° / 1.157 fs (XLOG)







Short term jitter* @ 12 GHz:

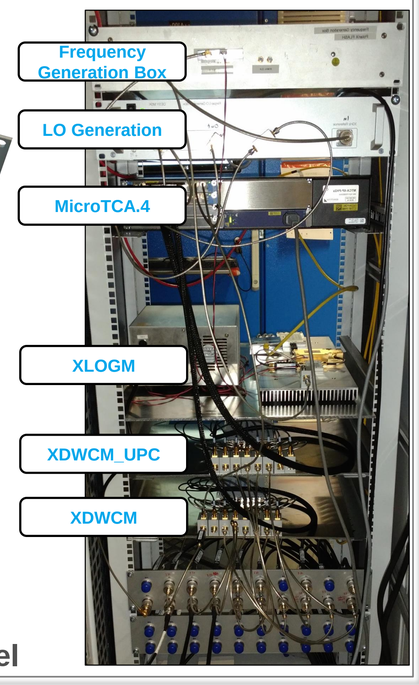
- 1.92 m° / 0.444 fs (XDWC)
- 4.85 m° / 1.123 fs (XUPC)

*Bandwidth 1 Hz – 10 MHz

Modules & Setup

Features of XLOGM:

- Frequency tripling
- Filtering of harmonic frequencies
- Amplifying of 9 GHz signal
- LO power for up to 4 XDWCM
- In-module power supply
- Includes Temperature Monitoring Control Board (TMCB), a standard digitizer board



Features of XDWCM:

- Completely passive module
- 8 conversion channels
- Variation: XDWCM_UPC with Up-conversion channel

First Results

- First streaking done on 5th September 2019
- Variable streaking principle proven on 9th September 2019

Conclusion & Outlook

- The additional conversion hardware adds about 1 fs of phase noise
- Packaging into 19” modules has been completed
  - Still needs to be installed
- Feed-forward control algorithm needs to be developed
- Current 125 MHz ADCs only yield a couple of sample points
- Installation of 2x PolariX in FLASH2 in 2020
- Installation of 2x PolariX in SINBAD in 2020

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